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Salomon et al.

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[54] **NUDGER FOR A MAIL HANDLING SYSTEM**

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[22] Filed: **Oct. 3, 1997**

[51] **Int. Cl.**[6] **B65H 07/08**

[52] **U.S. Cl.** **271/153**; 271/152; 271/155

[58] **Field of Search** 271/31.1, 117, 271/126, 149, 150, 152, 153, 154, 155; 414/798.9

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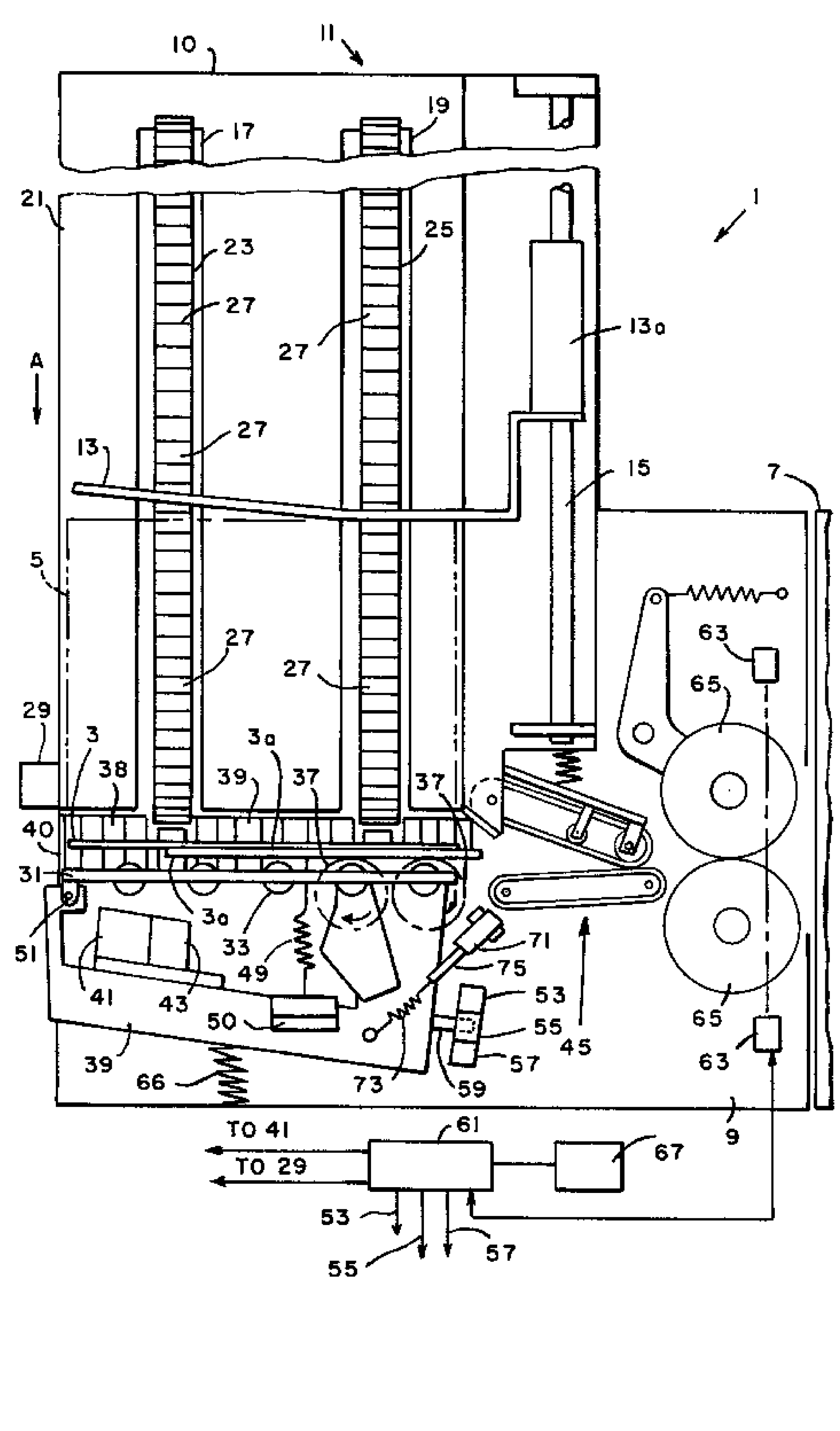
[57] **ABSTRACT**

A nudger including apparatus for applying a feed force to a lead mailpiece of the stack of mixed mail to feed the lead mailpiece of the stack along a mailpiece feed path, the applying apparatus being moveable between first and second positions; structure for biasing the applying apparatus against a face of the lead mailpiece thereby generating a stack force against a stack of mixed mail; and a stack advance mechanism for moving the stack of mixed mail so that the face of the lead mailpiece contacts the applying apparatus; wherein at times when the applying apparatus is in the first position the stack advance mechanism moves the stack of mixed mail in the direction of the applying apparatus causing the applying apparatus to move from the first position to the second position against the biasing structure such that the stack force increases causing a corresponding increase in the feed force; and further wherein at times when the applying apparatus is in the second position the stack advance mechanism stops moving the stack of mixed mail and the applying apparatus continuously feeds mailpieces away from the stack of mixed mail along the mailpiece feed path thereby continuously reducing the size of the stack of mixed mail so that the biasing structure gradually moves the applying apparatus from the second position to the first position and the stack force gradually decreases during movement of the applying apparatus from the second position to the first position.

8 Claims, 8 Drawing Sheets



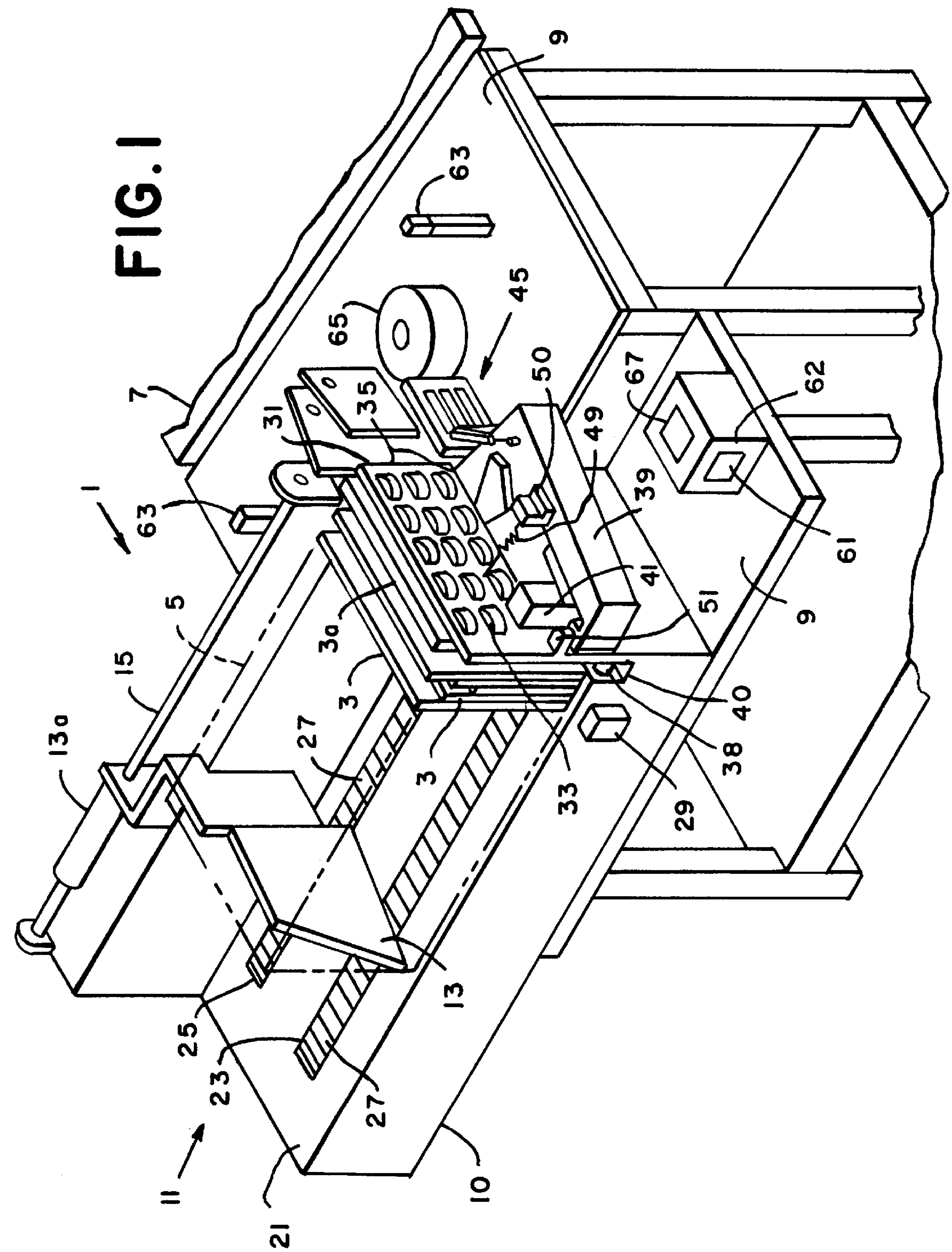
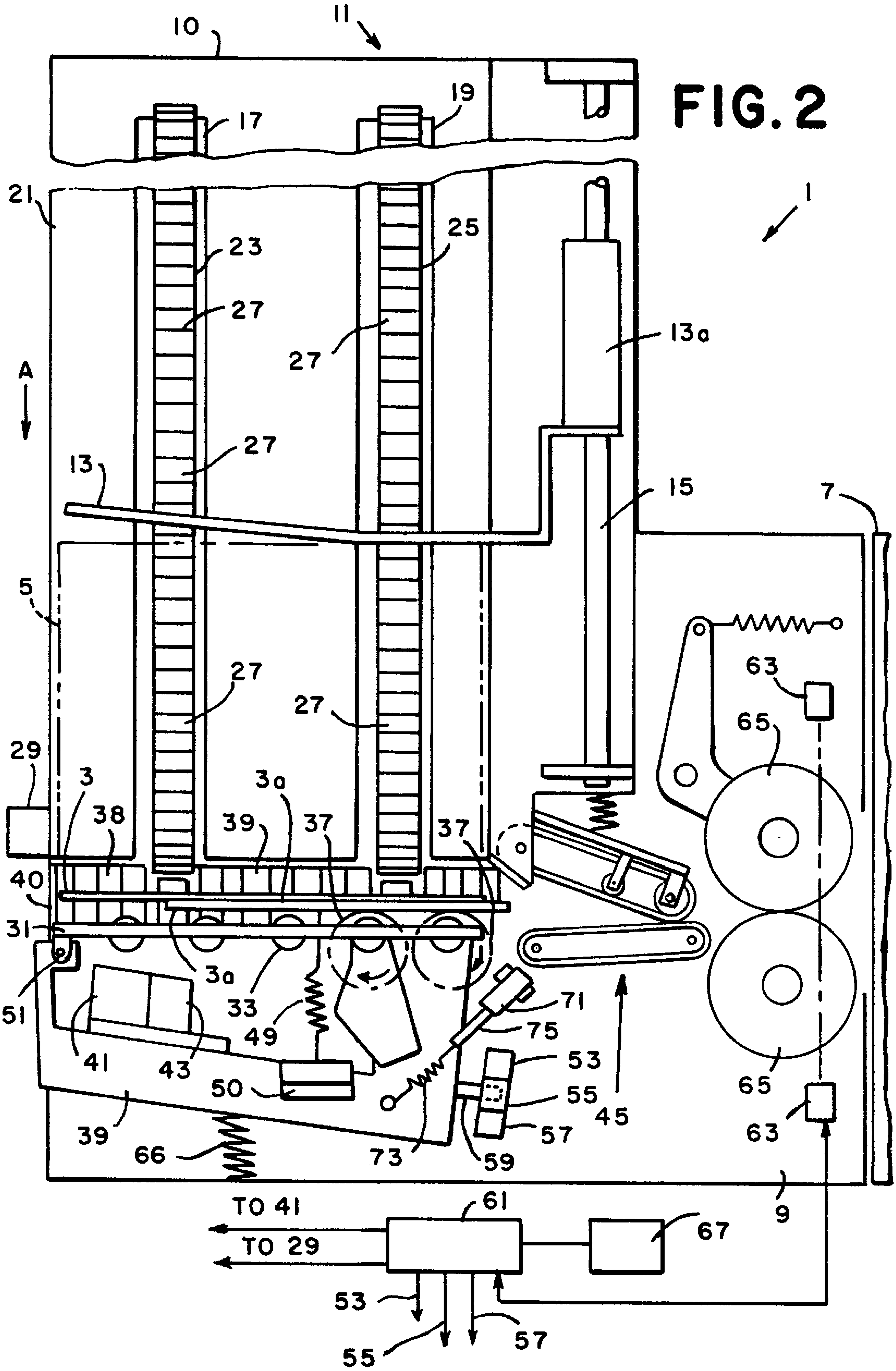


FIG. 1

FIG. 2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TO 41
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TO 29
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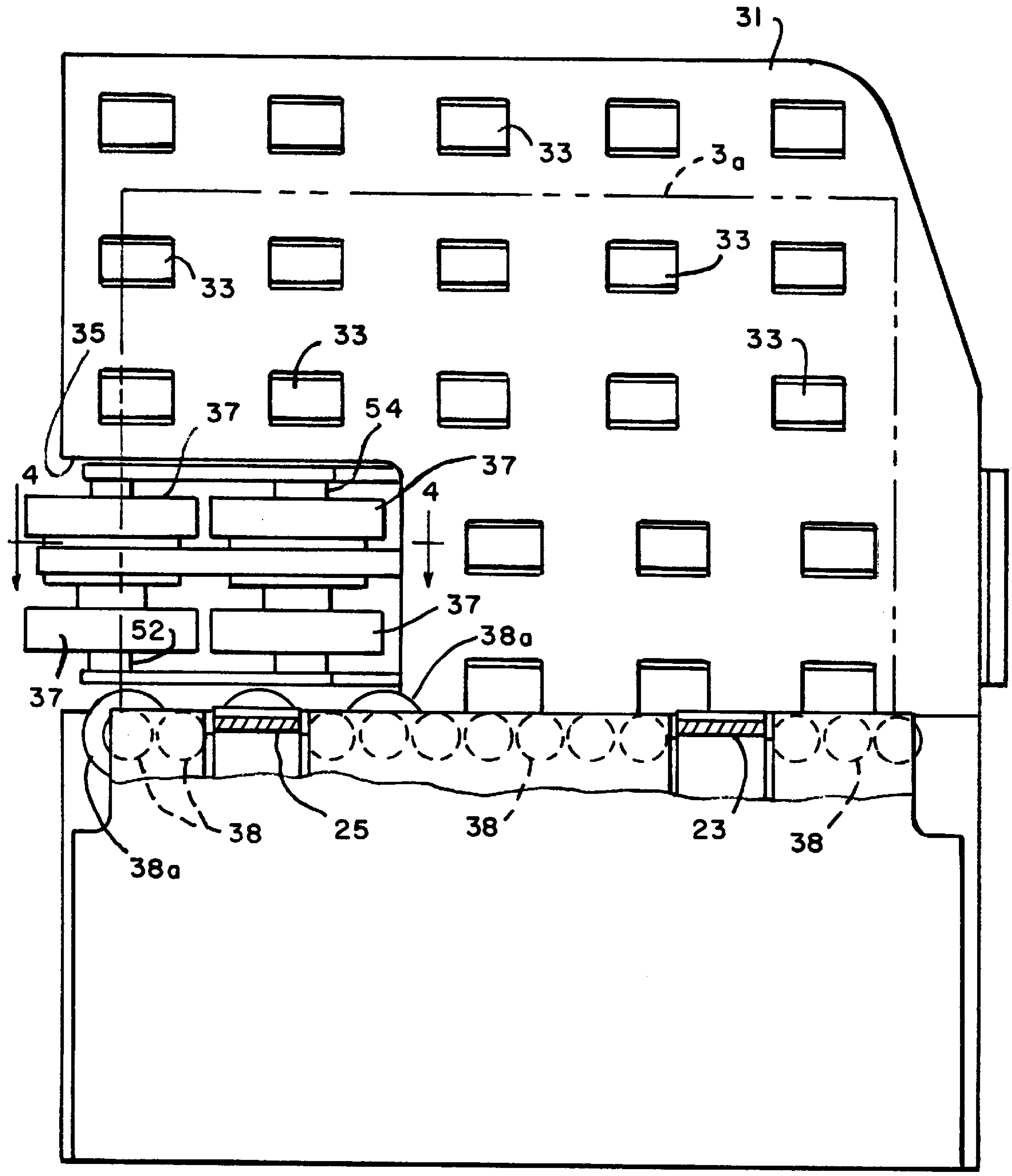
FIG. 3



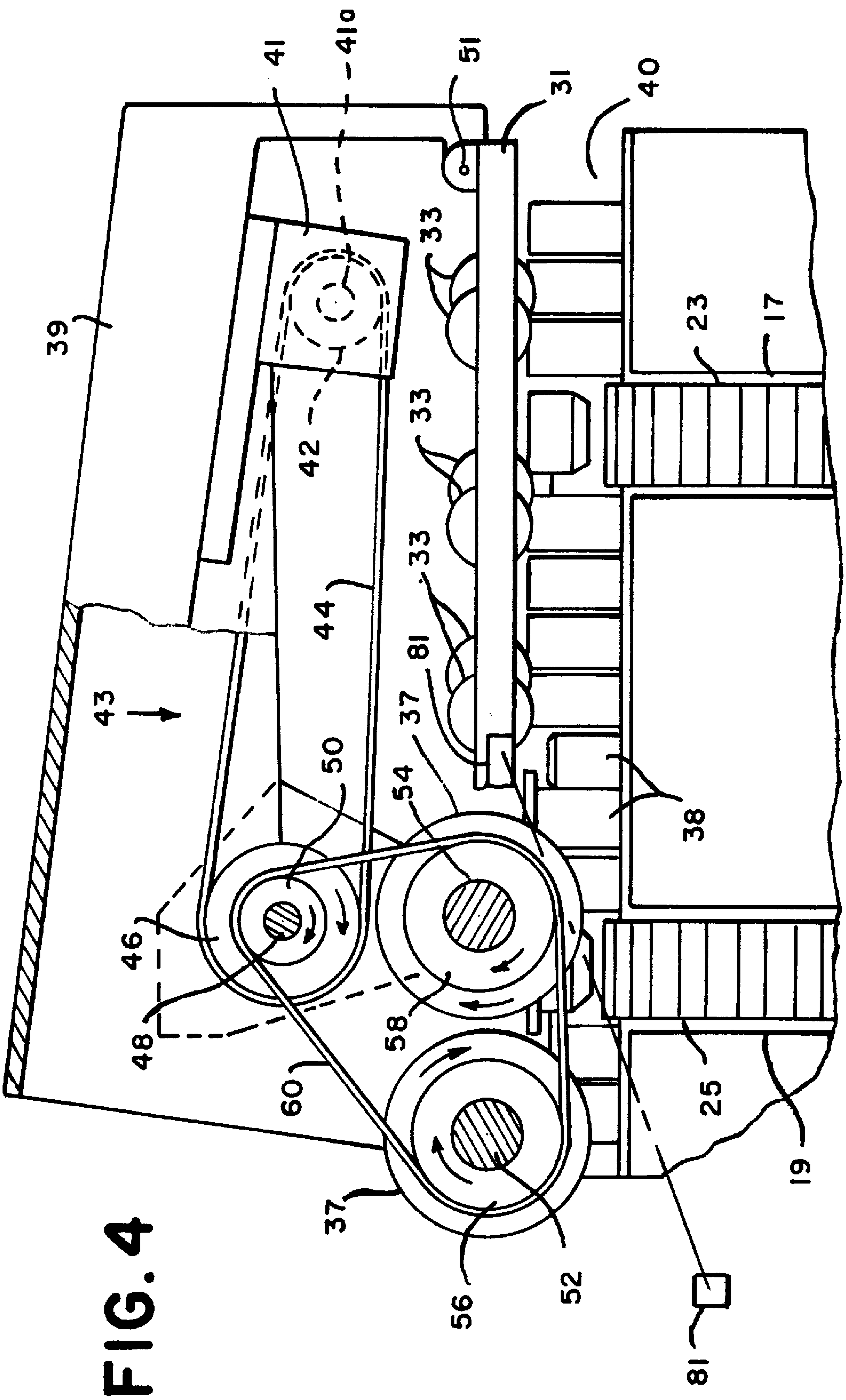

41a
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FIG. 4

FIG. 5

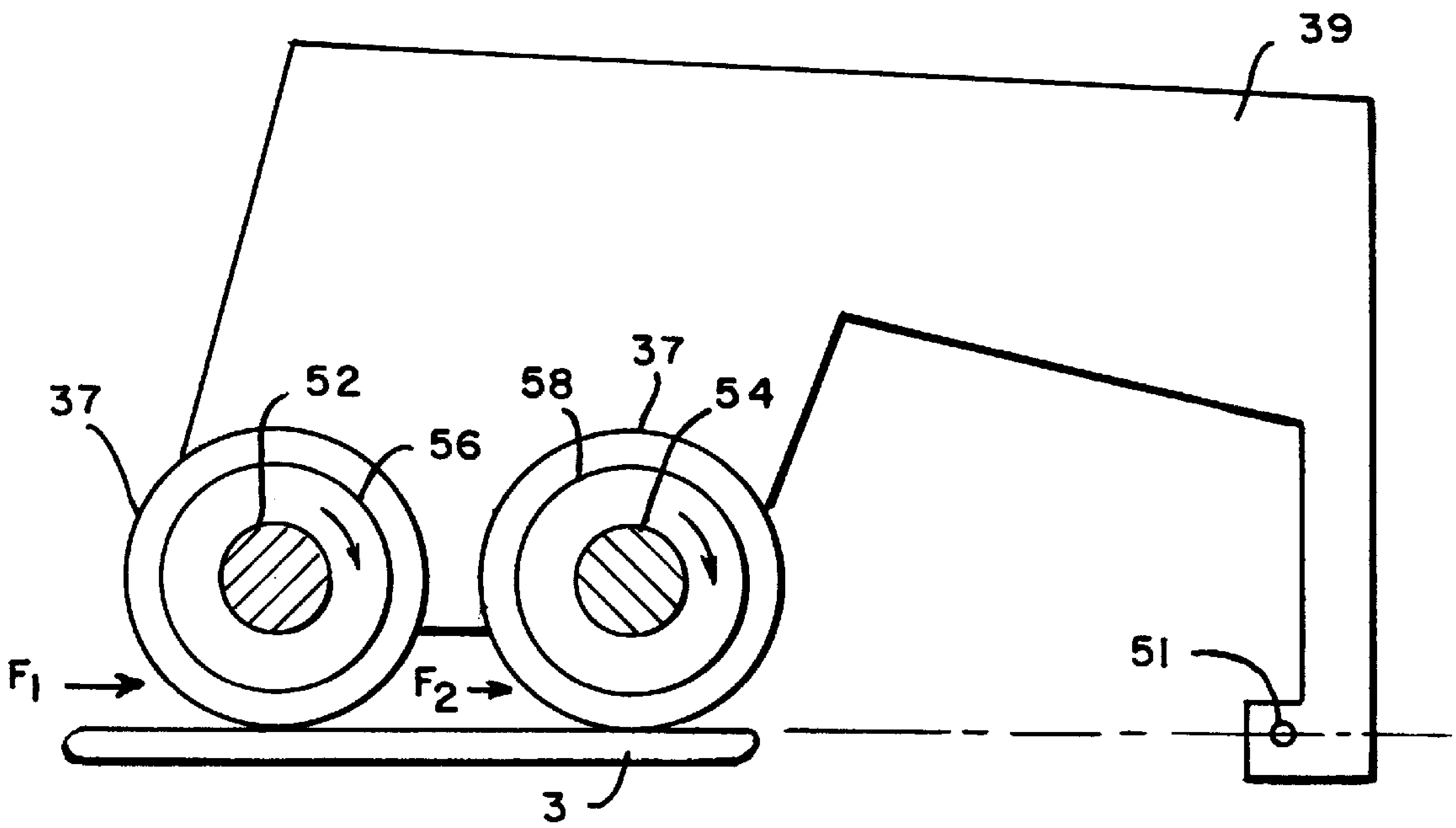


FIG. 7

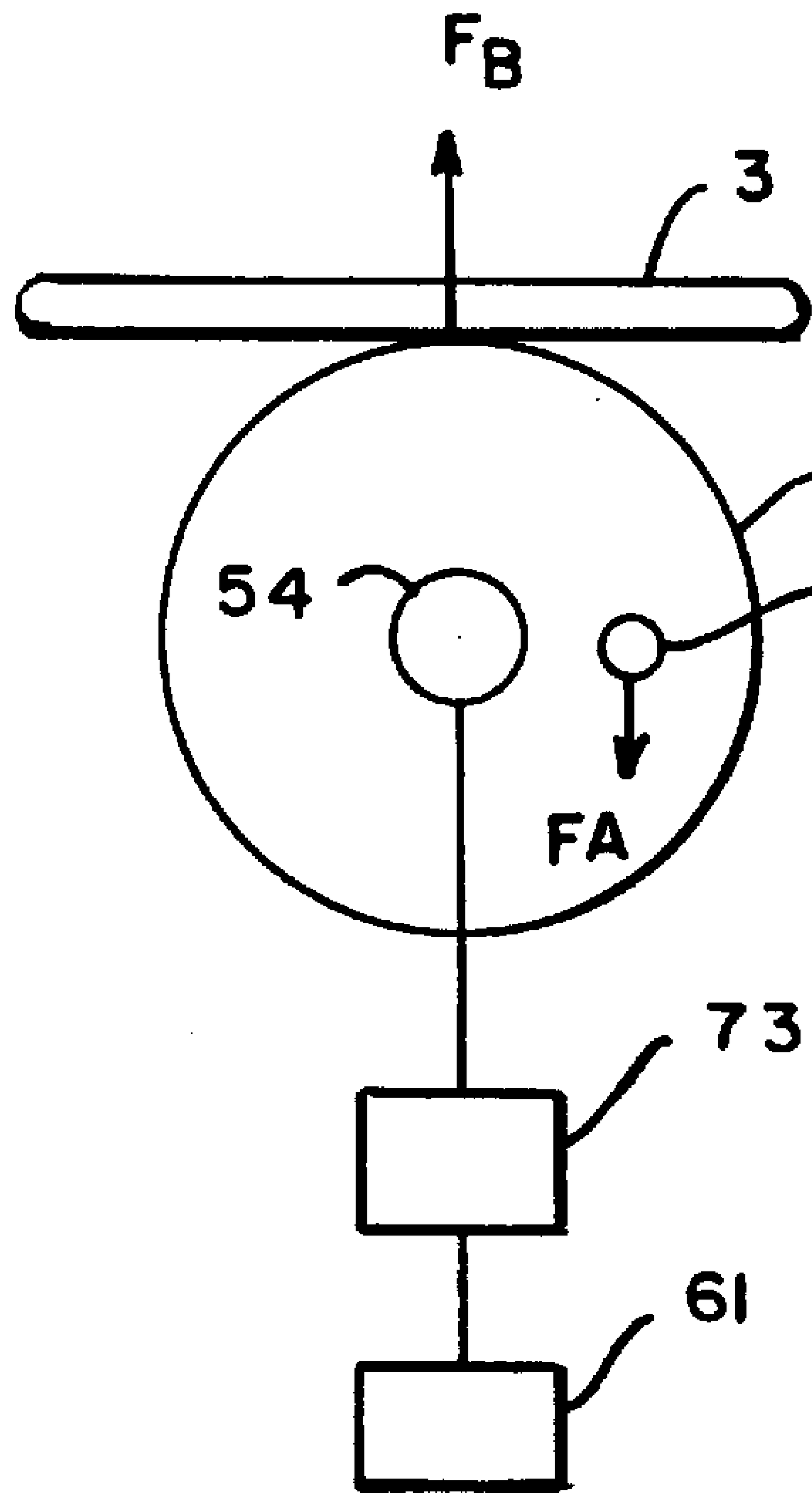
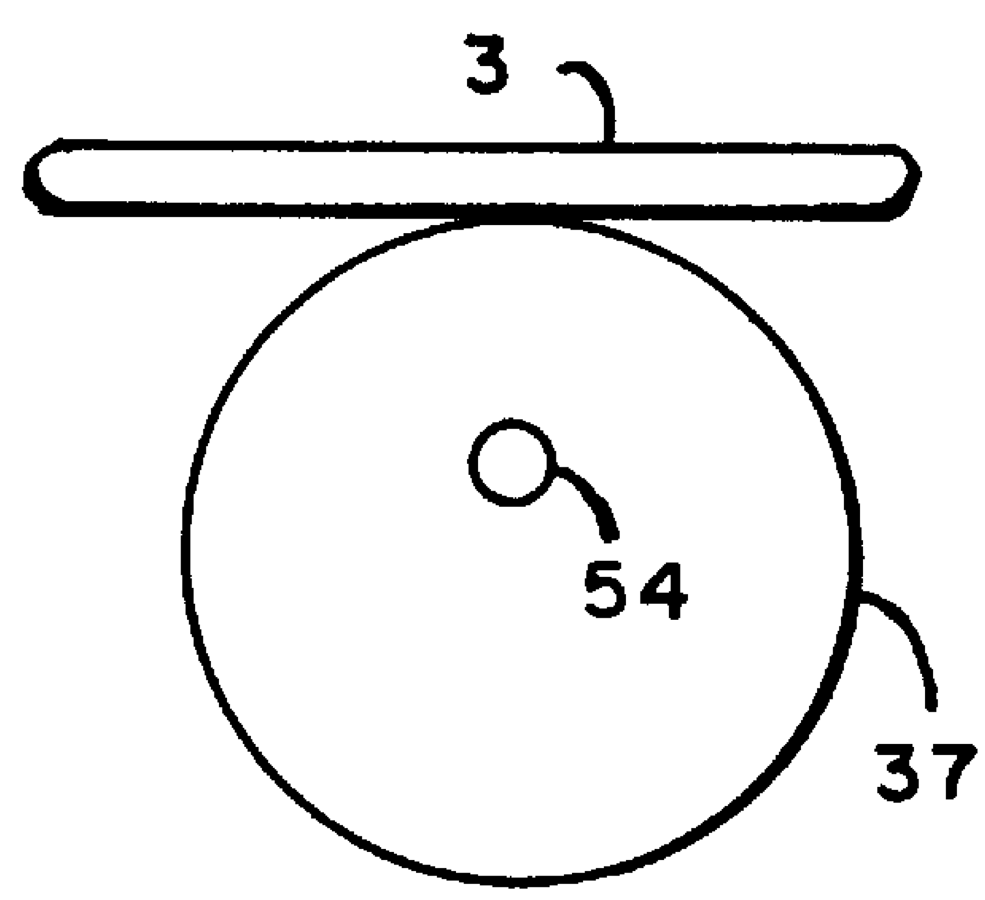


FIG. 8



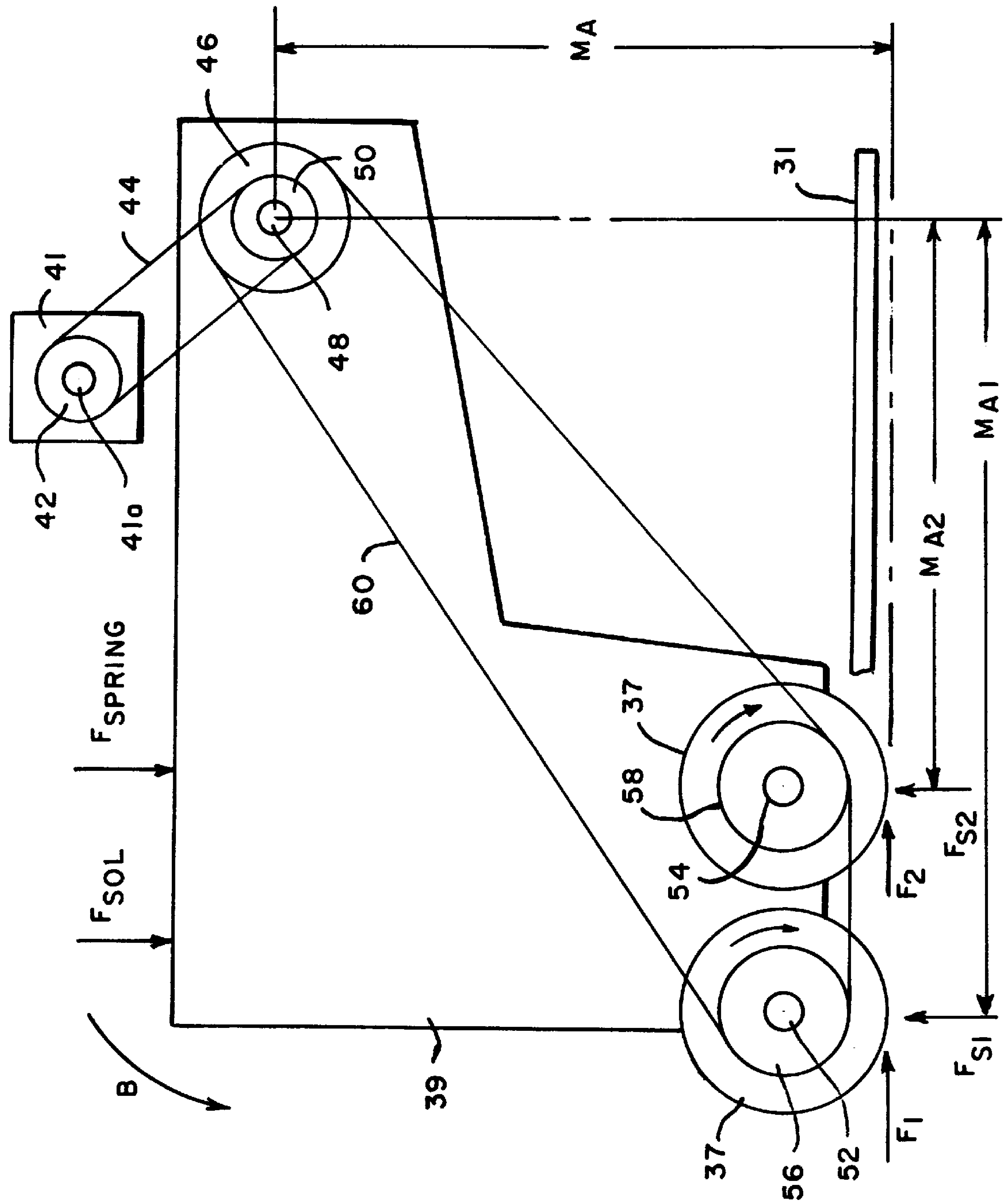


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FIG.6

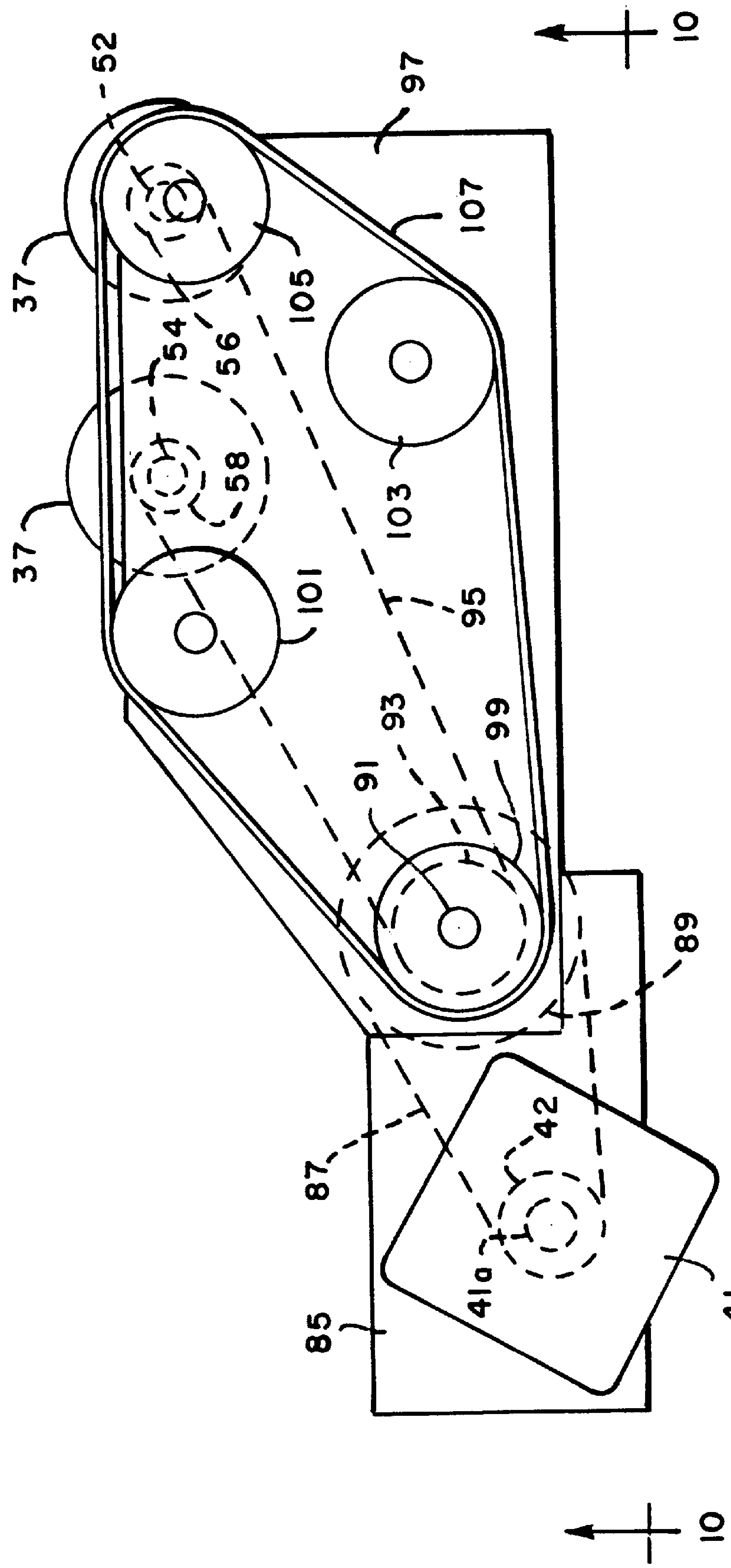
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FIG. 9

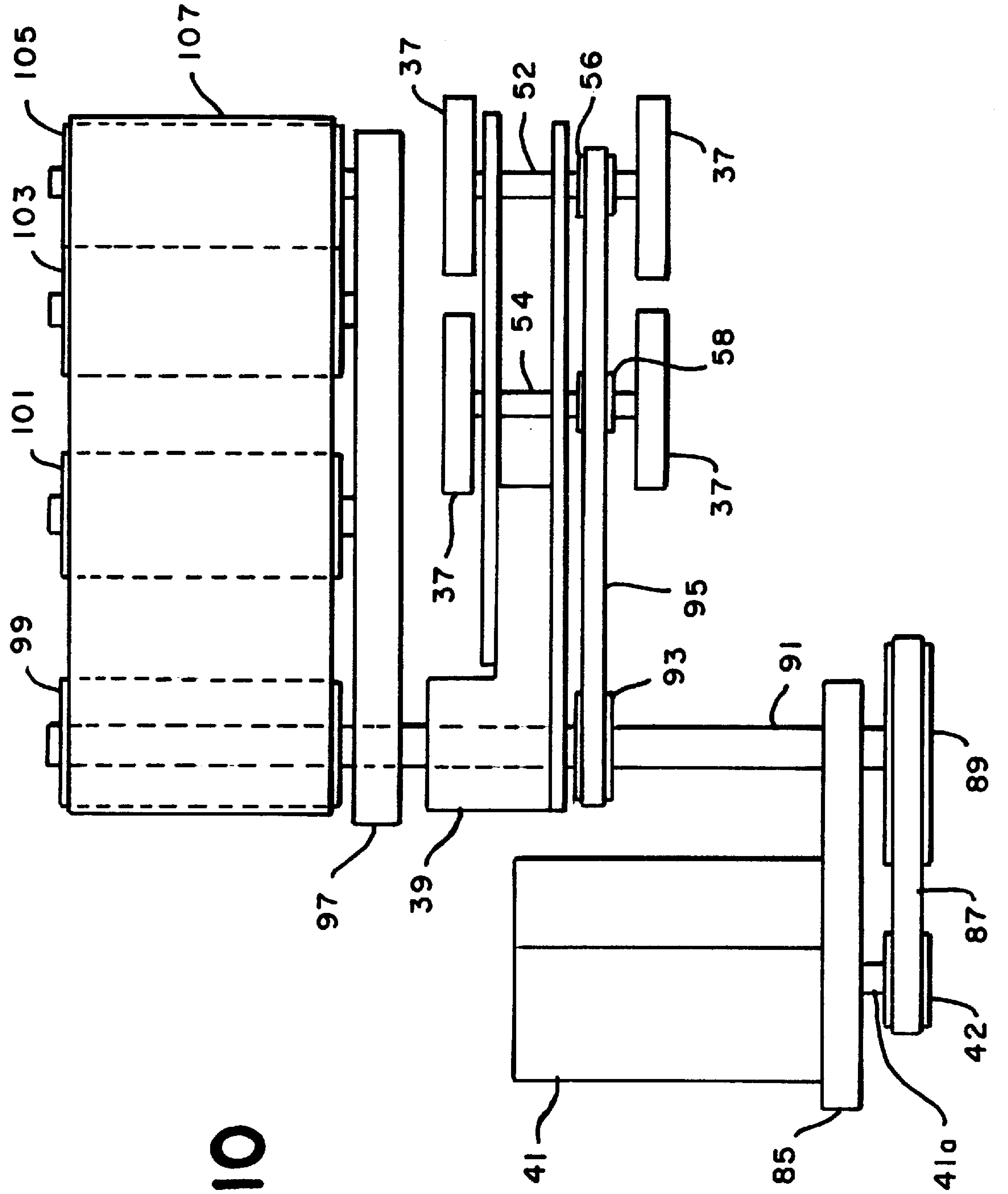

FIG. 10

NUDGER FOR A MAIL HANDLING SYSTEM

BACKGROUND

The processing and handling of mailpieces consumes an enormous amount of human and financial resources, particularly if the processing of the mailpieces is done manually. The processing and handling of mailpieces not only takes place at the Postal Service, but also occurs at each and every business or other site where communication via the mail delivery system is utilized. That is, various pieces of mail generated by a plurality of departments and individuals within a company need to be collected, sorted, addressed, and franked as part of the outgoing mail process. Additionally, incoming mail needs to be collected and sorted efficiently to ensure that it gets to the addressee in a minimal amount of time. Since much of the documentation and information being conveyed through the mail system is critical in nature relative to the success of a business, it is imperative that the processing and handling of both the incoming and outgoing mailpieces be done efficiently and reliably so as not to negatively impact the functioning of the business.

In view of the above, various automated mail handling machines have been developed for processing mail (removing individual pieces of mail from a stack and performing subsequent actions on each individual piece of mail). However, in order for these automatic mail handling machines to be effective, they must process and handle "mixed mail." The term "mixed mail" is used herein to mean sets of intermixed mailpieces of varying size, thickness, and weight. In addition, the term "mixed mail" also includes stepped mail (i.e. an envelope containing therein an insert which is smaller than the envelope to create a step in the envelope), tabbed and untabbed mail products, and mailpieces made from different substrates. Thus, the range of types and sizes of mailpieces which must be processed is extremely broad and often requires trade-offs to be made in the design of mixed mail feeding devices in order to permit effective and reliable processing of a wide variety of mixed mailpieces.

In known mixed mail handling machines which separate and transport individual pieces of mail away from a stack of mixed mail, the stack of "mixed mail" is first loaded onto some type of conveying system for subsequent sorting into individual pieces. The stack of mixed mail is moved as a stack by an external force to, for example, a shingling device. The shingling device applies a force to the lead mailpiece in the stack to initiate the separation of the lead mailpiece from the rest of the stack by shingling it slightly relative to the stack. The shingled mailpieces are then transported downstream to, for example, a separating device which completes the separation of the lead mailpiece from the stack so that individual pieces of mail are transported further downstream for subsequent processing. In the mailing machine described immediately above, the various forces acting on the mailpieces in moving the stack, shingling the mailpieces, separating the mailpieces and moving the individual mailpieces downstream often act in a counterproductive manner relative to each other. For example, inter-document stack forces exist between each of the mailpieces that are in contact with each other in the stack. The inter-document stack forces are created by the stack advance mechanism, the frictional forces between the documents, and potentially electrostatic forces that may exist between the documents. The inter-document forces tend to oppose the force required to shear the lead mailpiece from the stack.

Additionally, the interaction of the force used to drive the shingled stack toward the separator and the forces at the separator can potentially cause a thin mailpiece to be damaged by being buckled as it enters the separator. Furthermore, in a conventional separator, there are retard belts and feeder belts that are used to separate the mailpiece from the shingled stack. Both the forces applied by the retard belts and the feeder belts must be sufficient to overcome the inter-document forces previously discussed. However, the force of the retard belts cannot be greater than the force of the feeder belts or the mailpieces will not be effectively separated and fed downstream to another mail processing device. Moreover, if the feeding force being applied to the mailpieces for presenting them to the separator is too great, another potential problem which may occur is that a plurality of mailpieces will be forced through the separator without the successful separation of the mailpieces.

In view of the above, it is recognized that large forces are desirable to act on the mailpieces to accelerate and separate the mailpieces in a reliable and efficient manner. However, these same high forces can damage the mailpieces being processed (i.e. buckled lightweight mailpieces). Conversely, if the forces used to accelerate and separate the mailpieces are too small, poor separation, a lower throughput, and stalling of the mailpieces being processed will result. Put in another way, thin mailpieces are weak and require low forces to prevent them from being damaged, while thick/heavy mail is strong and requires high forces for proper separation and feeding. Thus, the structure used to separate a stack of mixed mail must take into account the counterproductive nature of the forces acting on the mailpieces and be such that an effective force profile acts on the mailpieces throughout their processing cycle so that effective and reliable mailpiece separation and transport at very high processing speeds (such as four mailpieces per second) can be accomplished without physical damage occurring to the mailpieces. However, since the desired force profile acting on a particular mailpiece is dependent upon the size, thickness, configuration, weight, and substrate of the individual mailpiece being processed, the design of a mixed mail feeder which can efficiently and reliably process a wide range of different types of mixed mailpieces has been extremely difficult to achieve.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a nudger for a mail handling system which is effective in processing mixed mail from a stack of mixed mail. The above object is met by providing a nudger including apparatus for applying a feed force to a lead mailpiece of the stack of mixed mail to feed the lead mailpiece of the stack along a mailpiece feed path, the applying apparatus being moveable between first and second positions; structure for biasing the applying apparatus against a face of the lead mailpiece thereby generating a tack force against a stack of mixed mail; and a stack advance mechanism for moving the stack of mixed mail so that the face of the lead mailpiece contacts the applying apparatus; wherein at times when the applying apparatus is in the first position the stack advance mechanism moves the stack of mixed mail in the direction of the applying apparatus causing the applying apparatus to move from the first position to the second position against the biasing means such that the stack force increases causing a corresponding increase in the feed force; and further wherein at times when the applying apparatus is in the second position the stack advance mechanism stops moving the stack of mixed mail and the applying apparatus continuously feeds mailpieces away from the stack of mixed mail along the mailpiece feed path thereby continuously reducing the size of the stack of mixed mail so that the biasing structure gradually moves the applying apparatus from the second position to the first position and the stack force gradually decreases during movement of the applying apparatus from the second position to the first position.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate a presently preferred embodiment of the invention, and together with the general description given above and the detailed description of the preferred embodiment given below, serve to explain the principles of the invention.

FIG. **1** is a perspective view of the inventive mail handling machine;

FIG. **2** is an enlarged plan view of FIG. **1**;

FIG. **3** is an enlarged detailed view of the nudger wall of FIG. **1**;

FIG. **4** is an enlarged top plan view partially in section along line **4—4** of FIG. **3** showing details of the nudger roller drive system;

FIG. **5** is a schematic view of the reaction forces associated with the nudger arm, nudger rollers and mailpiece;

FIG. **6** is a second embodiment of the nudger arm, nudger rollers, and mailpiece orientation which utilizes the reaction forces between the nudger rollers and the mailpiece to drive the nudger arm into the mailpiece;

FIG. **7** shows a third embodiment of a nudger system;

FIG. **8** shows a fourth embodiment of a nudger system;

FIG. **9** shows a fifth embodiment including an additional driven belt assembly for feeding large pieces of mail; and

FIG. **10** is a view of FIG. **9** along line **10—10**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. **1** and **2**, a mixed mail feeder **1** is shown. Mixed mail feeder **1**, as will be discussed in more detail below, separates individual mailpieces **3** from a stack of mixed mail generally designated at **5** and transports the individual mailpieces **3** to a subsequent mail processing station **7**. Mail processing station **7** can be any one of a plurality of devices such as a meter for printing postage on the mailpiece **3**, an OCR reader for reading addresses off of the mailpiece **3**, a sorting device for sorting the individual mailpieces **3** to designated bins or areas, or even a scale that weighs the mailpiece. The key point is that the mixed mail feeder **1** functions to separate individual mailpieces **3** from a stack of mixed mail **5** and deliver the individual mailpieces **3** sequentially to the mail processing station **7**.

Mixed mail feeder **1** includes a table **9** upon which all of the components of the mixed mail feeder **1** are mounted. At an input end of the mixed mail feeder **1**, generally designated by the arrow **11**, the stack of mixed mail **5** is placed on edge by an operator in front of a guide wall **13**. Guide wall **13** acts as a support against which the stack of mixed mail **5** rests. Moreover, guide wall **13** includes a cylindrical portion **13***a* which is mounted to slide on a guide rod **15** fixedly attached to platform **10** which is mounted to table **9**.

Platform **10** has first and second slots **17**, **19**, in a horizontal surface **21** thereof. The slots **17**, **19** each permit a top portion of a respective individual continuous belt **23**, **25** to project therethrough. Belts **23**, **25** each have a plurality of individual track portions **27** over the full extent of the belts **23**, **25**. The bottom of guide wall **13** removably fits in adjacent track portions **27** of each of belts **23** and **25** so that guide wall **13** moves with belts **23**, **25** in the direction of arrow A (alternatively, a single belt can be used). Moreover, as guide wall **13** moves in the direction of arrow A with the belts **23**, **25**, the cylindrical portion **13***a* slides along guide rod **15** to keep the standing orientation of guide wall **13** in the position shown in FIG. **1**.

Continuous belts **23**, **25** are mounted in a conventional manner around a pulley at each end (not shown). One pulley is an idler pulley while the other is driven by a motor **29**. The motor **29** drives a common shaft (not shown) connected to the drive pulleys of each of the belts **23**, **25** such that the belts **23**, **25** will be driven at the same velocity to move around their respective idler and driven pulleys. Thus, as the belts **23**, **25** move around the pulleys in the direction of arrow A, the guide wall **13** moves therewith so that the entire stack of mixed mail **5** is moved toward a nudger wall **31**. As will be discussed in more detail below, the stack of mixed mail **5** will have individual mailpieces **3** moved from the stack downstream so that the stack of mixed mailpieces is continuously reduced in size. When the guide wall **13** has been moved to a point where it is desirable to add additional pieces of mixed mail to the stack, the guide wall **13** can be lifted out of the individual tracks **27** of the belts **23**, **25** by pulling the guide wall **13** up to rotate, via the cylindrical portion **13***a,* about the guide rod **15**. Once the bottom of the guide wall **13** is clear of the individual tracks **27** of the belts **23**, **25**, it can be slid backward in the opposite direction from that of arrow A and placed in a desired position to receive additional mixed mail.

Referring to FIGS. **1**, **2**, and **3**, nudger wall **31** includes a plurality of rollers **33** mounted therein in a conventional manner to be freely rotatable. Furthermore, nudger wall **31** has a cutout **35** in a lower corner thereof through which driven nudger rollers **37** project. Moreover, a plurality of roller bars **38** are rotatably mounted in a conventional manner in a slot **40** of platform **10**. Thus, as guide wall **13** pushes the stack of mixed mail **5** toward nudger wall **31**, individual pieces of mail **3** fall off the end of belts **23**, **25** on top of the rollers **38** and into contact with the nudger rollers **37**. While in the preferred embodiment the roller bars **38** are not driven, they could be driven to provide additional forward feed force to the mailpiece **3**. In one embodiment, a continuous belt (not shown) is driven around the roller bars **38**. The use of the continuous belt provides a greater coefficient of friction as compared to the roller bars and thus improves the feed force and provides for a simple drive structure.

The nudger rollers **37** are mounted to be driven into rotation within a nudger arm **39**. The four nudger rollers **37** are driven together by a motor **41**, mounted on nudger arm **39**, via a drive train **43** as shown schematically in FIG. **2** and in detail in FIG. **4**. As shown in FIGS. **2** and **4**, all of the nudger rollers **37** are driven into rotation in a clockwise direction. Accordingly, as the stack of mixed mail **5** is moved toward nudger wall **31**, the lead mailpiece **3***a* is forced into contact with the nudger rollers **37**. The force of the driven nudger rollers **37** acts against the lead mailpiece

3*a* to move the mailpiece **3***a* in the direction of a conventional separator device **45**, thereby shingling the lead mailpiece **3***a* from the stack of mixed mail **5** as shown in FIGS. **1** and **2**. The shingled stack is then transported to the nip of separator **45** which operates in a conventional manner to separate the lead mailpiece **3***a* from the shingled stack and deliver it to take-away rollers **65** which transport the individual lead mailpiece **3***a* further downstream to mail processing station **7**.

Referring to FIGS. **3** and **4**, the details of the drive system **43** are shown. Motor **41** has a shaft **41***a* connected to a pulley **42**. A continuous belt **44** is disposed around pulley **42** and a second pulley **46**. Pulley **46** is fixedly mounted to a rotatable shaft **48** mounted in nudger arm **39**. Also, fixedly mounted to shaft **48** is a third pulley **50**. Additional shafts **52**, **54** are also rotatably mounted in nudger arm **39** and respectively have fourth and fifth pulleys **56**, **58** fixedly mounted thereto. Nudger rollers **37** are mounted on a corresponding one of shafts **52**, **54**. Accordingly, as motor **41** rotates pulley **42** in the clockwise direction of FIG. **4**, pulley **46** and hub **48** are driven in the clockwise direction as well. Since a continuous belt **60** passes around pulleys **50**, **56**, and **58**, shafts **52**, **54** are forced to rotate in the clockwise direction causing a corresponding rotational movement in all of nudger rollers **37**.

In order for the nudger rollers **37** to effectively feed the stack of mixed mail into the separator **45**, accurate control of the normal force applied to the stack of mixed mail **5** by the interaction of the guide wall **13** and the nudger rollers **37** needs to be achieved. The normal force is created by a spring **49** that is fixedly mounted at one end to the nudger wall **31** and at its other end to a mounting platform **50** of nudger arm **39**. The nudger arm **39** is pivotally mounted about a conventional pivot structure **51** so that the spring **49** biases the nudger rollers **37** through the cutout **35** and into contact with the lead mailpiece **3***a*. Thus, as the guide wall **13** is advanced in the direction of the nudger wall **31**, the nudger arm **39** is forced to rotate in the clockwise direction of FIG. **2** around pivot structure **51** in opposition to the biasing force of the spring **49**. As the spring **49** is extended due to the rotation of nudger arm **39** about the pivot structure **51**, the force exerted by the spring **49** is continually increased by a known amount.

As discussed above, it is desirable to regulate the amount of normal force being exerted by the spring **49**, via the nudger rollers **37**, on the stack of mixed mailpieces **5** to ensure that only the minimal amount of normal force required to permit the nudger rollers **37** to move each of the mixed mailpieces **3** toward the separator **45** is applied. That is, it is not desirable to continuously run motor **29** to constantly advance the guide wall **13** toward the nudger wall **31**. If this occurs, spring **49** will be extended to a length that applies too great a normal force on the lead mailpiece **3***a*. While this greater normal force may be acceptable for feeding heavier mailpieces **3** toward the separator **45**, it can create a significant problem for very thin mailpieces and untabbed mailpieces. That is, as the thin and untabbed mailpieces are fed by the nudger rollers **37** into the separator **45**, they can easily be buckled and damaged due to the feeding force of the nudger rollers **37** and the forces exerted by separator **45**. Additionally, if the guide wall **13** is advanced too far toward the nudger wall **31** the stack of mixed mail **5** will be clamped in place preventing the feeding of individual mailpieces from stack **5**. To prevent this from happening, the contact point of the nudger rollers **37** against the lead mailpiece **3***a* is always maintained closer to the stack **5** than the facing surface of the nudger wall **31** is to the stack **5**. This is accomplished by ensuring that the rotation of arm **39** is controlled (as discussed in more detail below) so that the contact point of the nudger rollers **37** against the mailpieces occurs between 7 to 16 millimeters away from guide wall **31** (contact point of rollers **37** extends beyond wall **31** in this range). This configuration permits the guide wall **31** to provide support to large mailpieces while at the same time it does not provide a surface at which the mailpieces can be clamped in place. Correspondingly, if the guide wall **13** is not advanced sufficiently enough toward nudger wall **31**, the spring **49** will only be extended to provide a very small normal stack force. If this force is too small, the action of the driven rotating nudger rollers **37** on the lead mailpiece **3***a* will be insufficient to overcome the inter-document forces existing between individual pieces of the stack of mixed mail **5** such that the shingling of the mailpieces **3** and the advancement of the shingled stack toward separator **45** will not occur and a stalled condition at nudger wall **31** occurs. Thus, as described above, the normal force which is created by the positioning of the mailpiece stack **5** against the nudger rollers **37** and the corresponding force created by the extension of spring **49** needs to be maintained in a range of 1–2 newtons in order to ensure that the various types of mixed mailpieces **3** which may be processed are properly shingled and fed vertically into the throat of separator **45** without being damaged or stalled at nudger wall **31**.

Since the normal force is provided by the extension of spring **49**, it can be controlled by accurately regulating the position of nudger arm **39** which correspondingly regulates the extension of spring **49**. That is, since the normal force applied by spring **49** is directly proportional to its extension, the normal force that it applies to the stack of mixed mail **5** is controlled by regulating the extension of spring **49**.

The aforementioned control of the extension of spring **49** and rotation of nudger arm **39** is accomplished via the utilization of conventional through-beam sensors **53**, **55**, and **57** and a finger **59** which projects from nudger arm **39**. As nudger arm **39** rotates about pivot structure **51**, the finger **59** will move between the three sensors **53**, **55** and **57**. When finger **59** blocks an individual one of the through-beam sensors **53**, **55**, and **57**, a signal is sent by the respective blocked through-beam sensor to a mixed mail feeder microprocessor **61** indicating the position of the finger **59** at the blocked sensor. The known position of the finger **59** corresponds to a known position of the nudger arm **39** and a known amount of extension of the spring **49**. Thus, at any of the positions where the finger **59** blocks one of the sensors **53**, **55**, and **57**, the exact normal force being applied by spring **49** through the nudger rollers **37** on the stack of mail **5** is known.

If the finger **59** is blocking the beam of the first sensor **53**, the microprocessor **61** knows that the nudger rollers **37** are at their innermost position relative to the stack of mixed mail **5**. At this position, the normal force exerted by spring **49** is below the desired minimum value of 1 newton and must be increased. The increase in normal force is created when the microprocessor **61**, in response to a signal from sensor **53**, energizes the motor **29** to move the belts **23** and **25** such that the guide wall **13** advances the mixed mail stack **5** into the nudger rollers **37**. The motor **29** will advance the stack of mixed mail **5** until the nudger arm **39** pivots about pivot structure **51** to the position where finger **59** blocks the through-beam sensor **55**. When this occurs, the sensor **55** sends a signal to microprocessor **61** which in turn deenergizes motor **29** stopping the advance of the stack of mixed mail **5** toward the nudger rollers **37**. In this position, the nudger rollers **37** are considered to be in the "out" position where the maximum desired normal force is being exerted on the lead mailpiece **3***a* due to the extension of the spring **49**. Subsequently, as mail is fed from the stack of mixed mail **5** toward the separator **45** due to the action of the rotating nudger rollers **37**, the nudger rollers **37** gradually move toward the innermost normal force position. When the nudger arm **39** has rotated inwardly such that the nudger rollers **37** are in the innermost normal force position, microprocessor **61** receives a signal from sensor **53** and energizes motor **29** to advance the stack of mail **5** until the second sensor **55** is blocked by the finger **59**. In this manner, constant regulation of the normal force in the predetermined range is maintained.

In a first preferred embodiment, the automatic control of the normal force, as described above, would only use the sensors **53** and **55** to ensure that the normal force generated by the nudger rollers **37** stays within the predetermined desired normal force range. However, in a second preferred embodiment, a second tier of additional stack force can be applied if it is determined that a mailpiece **3** has stalled at the nudger rollers **37** or at the separator **45**. That is, it is possible, since the mixed mail feeder **1** is designed to handle many different types of mixed mail, that a very heavy piece of mail may have stalled (become stuck) at the nudger rollers **37** or separator **45**. This situation would occur when the normal force applied by the nudger rollers **37** is insufficient to shingle the heavier mailpieces from the stack of mixed mail **5** and move the shingled stack downstream into the nip of the separator **45**. If stalling occurs, the mixed mail feeder **1** is essentially in a jammed or inoperative position. The way in which the mixed mail feeder **1** determines that a stall has occurred is by the use of a through-beam sensor **63**, which is positioned proximate to the nip of takeaway rollers **65**. Takeaway rollers **65**, in a conventional manner, receive individual mailpieces from separator **45** and move the individual mailpieces **3** downstream. Thus, if the takeaway rollers **65** feed a first mailpiece and do not process a second mailpiece **3** downstream in a predetermined period of time of, for example, 1,000 msec, the through-beam of sensor **63** does not detect the lead edge of the second mailpiece during that same predetermined time period. If the microprocessor **61** does not receive an indication from the sensor **63** that a leading edge of the second mailpiece has passed thereby within the predetermine period of time, microprocessor **61** is programmed to assume that a stall has occurred somewhere upstream. Microprocessor **61** then energizes motor **29** to cause the stack of mixed mail **5** to be moved toward the nudger wall **31**. The nudger arm **39** is forced to rotate about the pivot point **51** and the spring **49** is further extended. Motor **29** is driven until nudger arm **39** is advanced to block the third sensor **57**. In this position, a stalled normal force, which is larger than the maximum normal force applied under normal operating conditions, is being exerted on the lead mailpiece **3***a* by the nudger rollers **37** and the motor **29** is rendered inoperative by microprocessor **61**. The increased normal force can simply be due to the further extension of the spring **49** as the nudger arm **39** is rotated from its position blocking sensor **55** to its position blocking sensor **57**, or can be further increased by the force of an additional compression spring **66** which only contacts the nudger arm **39** to provide an additional spring force thereto when the nudger arm **39** moves beyond the position from the blocking of sensor **55** toward the blocking of sensor **57**. Assuming that the additional normal force applied is sufficient to move the stalled mailpiece **3**, the takeaway sensor **63** will provide an input to the microprocessor **61** identifying that the lead edge of the stalled mailpiece has passed thereby and the processing of individual mailpieces **3** will continue by driving the nudger rollers **37** until the nudger arm **39** moves to a position where the first sensor **53** is blocked by finger **59**. At this position, the system will operate as discussed above, regulating a force profile by maintaining the position of nudger arm **39** between the sensors **53** and **55**. In the event however, that even the additional normal force provided by the movement of the nudger arm **39** to block the sensor **57** does not correct the stalled problem, the microprocessor **61**, after a predetermined period of time, will provide an input to the user via a display **67** identifying the stalled condition and advising that operator intervention is required to correct the problem. As is readily apparent to one skilled in the art, the microprocessor **61** controls all of the motors typically associated with the stack advance, shingling device, separator, and take away rollers and includes known clock structure for determining the predetermined time periods discussed above. Empirical testing has shown that for the anticipated mixed mailpiece profile the additional normal force applied during movement of finger **59** from sensor **55** to sensor **57** goes from 2 to 5 newtons. Preferably, the spring **66** is selected and preloaded so that upon initial engagement with arm **39** the total normal force immediately goes to 4 newtons.

In yet another embodiment of the invention, a different mechanism is used to provide additional force in the situation where stalled mail is detected. That is, once the microprocessor **61** determines that a stall has occurred, utilization of a solenoid **71** and another spring **73** provides additional normal force in an attempt to overcome the stalled situation. The solenoid **71** is fixedly mounted to the platform **9** and the spring **73** has one end fixedly mounted to the nudger arm **39** and a second end fixedly mounted to a moveable plunger **75** of solenoid **71**. When the nudger arm **39** is positioned in the normal force operating range, the spring **73** is slack, thereby providing no additional normal spring force. However, when stalled mail is detected, the microprocessor **61** energizes the solenoid **71** to withdraw the plunger **75** such that the spring **73** is extended to provide an additional normal force to the mixed mail stack **5** via the nudger rollers **37**. The force applied by the solenoid/spring combination **71/73** can be consistently applied for a predetermined period of time or can be pulsed to help the stalled mail break away. Moreover, in a more complex arrangement, different levels of force can be applied by the spring **73** and solenoid **71** combination over a predetermined time period in an attempt to break the stalled mailpiece away. The gradual application of increased forces has the benefit of not immediately providing too great a force to the stalled mailpiece, which force could potentially damage the piece of mail if it is too great. The advantages of using the solenoid/spring **71/73** combination is that, unlike the previously described embodiments, the application of the additional force does not depend on the stack advance response time such that the stalled mail situation is corrected faster thereby improving the overall throughput of the mixed mail feeder. Additionally, the use of the solenoid/spring **71/73** combination reduces the range of nudger roller **37** motion, thereby directing the trajectory of the mail at the feeder closer to the optimum area. Finally, while FIG. **2** shows each of the springs **49**, **66** and **73**, each of these springs either alone or in combination can be used to provide the desired normal force.

In yet another embodiment of the invention, a more simplified mechanism for providing an increased normal force on the stack of mixed mail **5** is to offset the pivot of the nudger arm **39** so that the reaction force between the mail and the nudger rollers **37** pulls the nudger arm **39** against the mailpieces **3**, thereby providing additional stack force. This embodiment is best explained by first referring to FIG. **5** which schematically shows the relationship of nudger rollers **37** to the pivot point **51** of nudger arm **39** in the embodiment of FIGS. **1** and **2**. As shown, when nudger rollers **37** are driven, reaction forces F_1 and F_2 are respectively created due to the coefficient of friction between the nudger rollers **37** and the mailpiece **3**. Since these forces F_1, F_2 pass through the pivot point **51** of nudger arm **39**, they do not create a moment about pivot point **51** and thus do not affect the normal stack force as nudger arm **39** rotates. However, if the structure of FIG. **5** is changed as reflected in FIG. **6**, effective use of the reaction forces F_1 and F_2 can be made to automatically increase the normal force acting on the stack as the nudger rollers **37** move inboard toward the stack of mixed mail **5** as compared to the embodiment of FIG. **5**.

In FIG. **6**, motor **41** is no longer mounted on nudger arm **39** but is fixedly mounted to table **9** (not shown). The remaining structure of the nudger roller **37** drive system is the same as described in connection with FIG. **4**. However, in FIG. **6**, nudger arm **39** is mounted to pivot along the rotational axis of shaft **48**. The rotational axis of shaft **48** is located a distance "M_A" from the direction of the reaction forces F_1 and F_2 such that respective moments "F_1M_2" and "F_1M_2" "are created about the pivot axis of shaft **48**. Since the sum of the moments about the axis of shaft **48** is equal to zero, the following equation results.

$$M_A\times(F_1+F_2)+M_{ASPRING}\times F_{SPRING}+M_{ASOLENOID}\times F_{SOLENOID}=M_AF_{S1}+M_AF_{S2}+MOTOR\ DRIVE\ TORQUE$$

From the above equation, as nudger arm **39** rotates inwardly along arrow "B", the moment arms of the spring **49**, solenoid/spring **71**/**73**, and normal forces F_{s1} and F_{s2} decrease while the moment arm of the reaction forces F_1, F_2 increase. In the system of FIG. **5**, $M_A\times F_1\times F_2$ is zero and thus as the nudger arm rotates F_{s1} and F_2 decrease. However, in the structure of FIG. **6**, the increased M_A of F_1 and F_2 creates a larger moment about the axis of shaft **48** so that the stack forces F_1 and F_2, at any point during the inward rotation of nudger arm **39**, are greater than the corresponding stack forces at the same rotational position of the nudger arm **39** of FIG. **5**. Thus, additional stack force has been created in the embodiment of FIG. **6** by utilizing the reaction force between the nudger rollers **37** and mailpiece **3**. This apparatus requires no additional structure as compared to the FIG. **5** configuration and is automatically applied as nudger arm **37** moves. Moreover, since the reaction forces are dependent upon the coefficient of friction of the mailpiece **3**, the increased stack force varies depending on the coefficient of friction of the mailpiece **3**. It is important to not that one possessing ordinary skill in the art utilizing the instant disclosure can balance the spring design, the drive ratio, and the arm **39** geometry relative to the pivot point thereof to ensure the stack force applied during the full range of motion of arm **39** falls within a desired range.

Yet another way to provide an increased stack force on demand is to have a rotating imbalance on the nudger rollers **37**. That is, with reference to FIG. **7**, each nudger roller **37** has an offset center of gravity (CG) **71**. When the position of CG **71** is as shown in FIG. **7**, microprocessor **61** controls motor **41** to accelerate the nudger rollers **37**. The acceleration of the CG **71** results in a force F_A and a corresponding increased stack force F_B. A conventional encoder **73** operatively associated with shaft **54** provides signals to motor **61** indicative of the position of shaft **54** and thus of CG **71**. By timing the acceleration of the nudger rollers **37** properly, the acceleration of CG **71** provides more force into the stack and less force off the stack. This structure can be used in connection with sensor **63** to provide an increased pulsed stack force when a stall is detected.

Along similar lines, as shown in FIG. **8**, nudger rollers **37** can be mounted for eccentric rotation thereby using the reaction of the eccentric rollers against the inertia of the nudger arm **39** to provide additional stack force as well as increased extension of the spring **49**. In this embodiment, a periodic pulse force would consistently be applied during the driving of the nudger rollers **37**.

Another important factor in the design of the feeding and shingling structure is the minimization of drag. This is accomplished by the rollers **33** in the vertical nudger wall **31**, and the rollers **38** which support the bottom edge of the mailpieces **3**. The rollers **33** in the nudger wall **31** have their axes oriented vertically and are beveled (not shown) on their lower surface. This prevents mail that is leaning toward the nudger wall **31** from catching under the edge of the rollers **33** as it slides up to vertical. Some of the rollers **38** supporting the bottom edge of the mailpieces **3** have flanges **38***a* on them to prevent mail from getting caught in gaps in the mail path.

In the apparatus of FIG. **1**, nudger wall **31** extends above nudger rollers **37** and have idler rollers **33** which reduce friction on large mailpieces that extend above the nudger rollers **37**. However, Applicants have found that if the idler rollers extending above the nudger rollers **37** were replaced with a driven belt, the additional feed force provided by the belt assists in moving the large mailpieces toward the separator **45**. FIGS. **9** and **10** show the structure for providing such additional feed force. In this embodiment, nudger motor **41** is mounted to a deck **85** and drives pulley **42** into rotation via a shaft **41***a*. A continuous belt **87** is disposed around pulley **42** and a pulley **89** fixedly mounted to a main drive shaft **91** which itself is mounted for rotation in decks **85** and **97**. A pulley **93** is fixedly mounted on shaft **91**. A second continuous belt **95** is disposed around pulley **93** and nudger pulleys **56**, **58** such that as shaft **41***a* is driven by motor **41** the nudger rollers **37** are driven into rotation. Additionally, arm **39** is mounted to be freely rotatable about shaft **91**.

Shaft **91** extends above deck **97** and has a first roller **99** fixedly mounted thereon. In addition, idler rollers **101**, **103**, and **105** are each mounted for rotation about respective shafts extending from deck **97**. A continuous belt **107** is disposed around each of the rollers **99**, **101**, **103**, and **105** such that as shaft **91** is driven into rotation belt **107** rotates in the same direction as the nudger rollers **37**.

Referring specifically to FIG. **9**, the nudger rollers **37** will always extend beyond the belt **107** such that only the leaning portion of the tops of large mailpieces will contact belt **107**. Moreover, the sizing of the pulleys in the drive train is such that the belt **107** is driven at a lower or the same velocity as the nudger rollers **37**.

Additionally, the mail handling system **1**, as shown in FIG. **4**, includes a through-beam sensor **81** which projects a beam across opening **40** in the vicinity of nudger rollers **37**. As mailpieces enter opening **40**, sensor **81** is blocked identifying their presence such that microprocessor **61** operates motor **41** to drive the nudger rollers **37**. However, if sensor **81** is not blocked, the nudger rollers **37** are not driven.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details, and representative devices, shown and described herein.

Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims.

What is claimed is:

1. A nudger for a mail handling system which processes a stack of mixed mail, the nudger comprising:

means for applying a feed force to a lead mailpiece of the stack of mixed mail to feed the lead mailpiece of the stack along a mailpiece feed path, the applying means being moveable between first and second positions;

means for biasing the applying means against a face of the lead mailpiece thereby generating a stack force against the stack of mixed mail;

a stack advance mechanism for moving the stack of mixed mail so that the face of the lead mailpiece contacts the applying means;

wherein at times when the applying means is in the first position the stack advance mechanism moves the stack of mixed mail in the direction of the applying means causing the applying means to move from the first position to the second position against the biasing means such that the stack force increases causing a corresponding increase in the feed force;

wherein at times when the applying means is in the second position the stack advance mechanism stops moving the stack of mixed mail and the applying means continuously feeds mailpieces away from the stack of mixed mail along the mailpiece feed path thereby continuously reducing the size of the stack of mixed mail so that the biasing means gradually moves the applying means from the second position to the first position and the stack force gradually decreases during movement of the applying means from the second position to the first position;

means for determining when mailpieces have stalled in the mailpiece feed path; and

means for exerting an additional stack force to the stack of mixed mail in response to the determined stall.

2. A nudger as recited in claim **1**, wherein the applying means includes an arm which is moveable between the first and second positions, a plurality of nudger rollers mounted for rotation in the arm, and means for driving the nudger rollers into rotation, end wherein the biasing means is a spring fixed at one end to ground and at the other end to the arm thereby biasing the plurality of nudger rollers against the lead mailpiece, the feed force created by the rotation of the rollers against the lead mailpiece.

3. A nudger as recited in claim **2**, further comprising means for controlling the stack advance mechanism and the applying means and means, operatively connected to the controlling means, for sensing the position of the arm and for providing an indication of the sensed position to the controlling means such that the controlling means operates and stops the stack advance mechanism when the arm is respectively in the first and second positions.

4. A nudger as recited in claim **3**, wherein the determining means is in communication with the controlling means and at times when the determining means determines that mailpieces have stalled the controlling means operates the stack advance mechanism to move the stack of mixed mail in the direction of the applying means until the arm is moved to a third position where the stack force generated by the spring is greater then the stack force generated by the spring when the arm is in the second position, the additional stack force being the difference between the stack force generated by the spring when the arm is in the third position and the stack force generated by the spring when the arm is in the second position.

5. A nudger as recited in claim **3**, wherein the means for exerting on additional stack force includes a solenoid, means for controlling operation of the solenoid, and a spring connected at one end to the applying means and at another end to the solenoid, and wherein upon the determination by the determining means that mailpieces have stalled the controlling means operates the solenoid to change the length of the spring such that the spring provides the additional stack force via the applying means.

6. A nudger as recited in claim **4**, further comprising a second spring which only contacts the arm at times when the arm is moved from the second position to the third position, the second spring providing a second additional stack force to the stack of mail.

7. A nudger as recited in claim **2**, further comprising an encoder operatively connected to the plurality of nudger rollers and to the drive means, the encoder sending an indication of the rotational position of the nudger rollers to the drive means, and wherein each of the plurality of nudger rollers has a center of gravity displaced from its axis of rotation and the drive means selectively accelerates rotation of the nudger rollers in response to a determination by the determining means that mailpieces have stalled thereby providing the additional stack force.

8. A nudger as recited in claim **2**, wherein as the arm moves between the first and second positions it pivots about an arm axis, as the nudger rollers rotate against the face of the lead mailpiece a reaction force is created between the lead mailpiece and the nudger rollers to create a moment about the arm axis, and the arm axis is located relative to the reaction force so that as the nudger rollers move with the arm from the second to the first position the moment increases pulling the arm toward the stack of mixed mail to increase the stack force.

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